

## 4.3 ETHYLENE PRODUCTION

### 4.3.1 Process Description

Ethylene is produced through pyrolysis of natural gas concentrates or petroleum fractions such as naphthas and atmospheric gas oils.<sup>28</sup> Pyrolysis gasoline is a liquid by-product formed as part of the steam-cracking process. The liquid pyrolysis gasoline is rich in benzene. Ethylene plants of the same production capacity, but using different feedstocks (ethane/propane versus naphthas/gas oils), will produce different amounts of pyrolysis gasoline with different benzene concentrations. For example, an ethylene plant producing 1 billion pounds (453.5 gigagrams [Gg]) of ethylene per year from ethane will produce about 16,097,023 lbs (7.3 Gg) pyrolysis gasoline with about 7,497,244 lbs (3.4 Gg) benzene in the pyrolysis gasoline.<sup>28</sup> A plant producing the same amount of ethylene from atmospheric gas oils will produce about 754,134,509 lbs (342 Gg) of pyrolysis gasoline containing 213,450,937 lbs (96.8 Gg) benzene.<sup>28</sup>

Because the benzene content of pyrolysis gasoline can be high, some plants recover motor gasoline, aromatics (BTX), or benzene from the pyrolysis gasoline. Table 4-1 lists facilities reported to recover benzene from pyrolysis gasoline. However, benzene can be emitted from ethylene plants that produce pyrolysis gasoline but do not recover benzene. Table 4-2 lists ethylene producers and their locations. To locate most of the potential sources of benzene from ethylene/pyrolysis gasoline plants, information is included here on ethylene/pyrolysis gasoline production, as well as information on recovery of benzene from pyrolysis gasoline. But because ethylene plants using naphthas/gas oils as feedstocks produce more pyrolysis gasoline and more often treat the gasoline prior to storage, these types of plants are emphasized in the following discussion.

Reference 28 provides more detailed information on ethylene plants using natural gas concentrates as feedstocks. In general, natural gas-using plants are less complex than naphtha-using plants. The potential emissions sources of benzene at the two types of

TABLE 4-2. ETHYLENE PRODUCERS - LOCATION AND CAPACITY

Producer	Location	Annual Capacity million lb (million kg)	Notes <sup>a</sup>
Atlantic Richfield Company Lyondell Petrochemical Company, subsidiary	Channelview, Texas	3,360 (1,524)	Partly captive
The BF Goodrich Company BF Goodrich Chemical Group	Calvert City, Kentucky	350 (159)	Merchant
Chemicals & Speciality Products Group	Alvin, Texas	2,384 (1,081)	Mostly merchant
Chevron Corporation Chevron Chemical Company, subsidiary Olefins and Derivatives Division	Cedar Bayou, Texas Port Arthur, Texas	1,450 (658) 1,250 (567)	Mostly captive Mostly captive use at Orange, Texas
Dow Chemical U.S.A.	Freeport, Texas Plaquemine, Louisiana	2,050 (930) 2,300 (1,043)	Captive Captive
Du Pont Du Pont Chemicals	Orange, Texas	1,050 (476)	Captive
Eastman Chemical Company Texas Eastman Company	Longview, Texas	1,400 (635)	Mostly Captive

(continued)

TABLE 4-2. CONTINUED

	Producer	Location	Annual Capacity	Notes <sup>a</sup>
			million lb (million kg)	
4-18	Exxon Chemical Company Exxon Chemical Americas	Baton Rouge, Louisiana Baytown, Texas	1,775 (805) 2,100 (953)	Captive Some captive use at Mont Belvieu, Texas
	Javelina Gas Processing	Corpus Christi, Texas	180 (82)	Recovered from gas by-products of local refineries; merchant
	Koch Industries, Inc. Koch Refining Company, subsidiary	Corpus Christi, Texas	24 (11)	Captive
	Mobil Oil Corporation Mobil Chemical Company, division Petrochemicals Division	Beaumont, Texas Houston, Texas	1,100 (499) 500 (227)	Mostly captive Mostly captive
	Occidental Petroleum Corporation Petrochemicals Olefins & Aromatics Division	Chocolate Bayou, Texas Corpus Christi, Texas Lake Charles, Louisiana	1,100 (499) 1,700 (771) 750 (340)	Mostly captive Mostly captive Captive
	Phillips Petroleum Company Chemicals Division Olefins and Cyclics Branch	Sweeny, Texas	2,550 (1,157)	Partly captive

(continued)

TABLE 4-2. CONTINUED

Producer	Location	Annual Capacity million lb (million kg)	Notes <sup>a</sup>
Quantum Chemical Corp. USI Division	Clinton, Iowa	900 (408)	Captive
	Deer Park, Texas	1,500 (680)	Captive
	Morris, Illinois	1,000 (454)	Captive
Rexene Corporation	Odessa, Texas	500 (228)	Partly captive
Shell Oil Company Shell Chemical Company, division	Deer Park, Texas	1,900 (862)	Partly merchant
	Noroco, Louisiana	2,560 (1,161)	Partly captive
Sun Refining and Marketing Co.	Brandenburg, Kentucky	NA	Captive
	Claymont, Delaware	250 (113)	Partly captive
Sweeny Olefins Limited Partnership	Sweeny, Texas	1,500 (680)	Merchant
Texaco Chemical Company	Port Arthur, Texas	1,150 (522)	Some captive use at Port Neches
	Port Neches, Texas	350 (159)	Captive
Union Carbide Corporation Industrial Chemicals Division	Seadrift, Texas	880 (399)	Captive
	Taft, Louisiana	1,405 (637)	Captive
	Texas City, Texas	1,400 (635)	Mostly captive

(continued)

TABLE 4-2. CONTINUED

Producer	Location	Annual Capacity million lb (million kg)	Notes <sup>a</sup>
Union Texas Petroleum/BASF Corporation/GE Petrochemicals, Inc. Chemical Company	Geismar, Louisiana	1,160 (526)	Captive
Vista Chemical Company	Lake Charles, Louisiana	920 (417)	Mostly captive
Westlake Petrochemicals Corporation	Sulphur, Louisiana	1,000 (454)	Mostly captive
TOTAL		45,798 (20,774)	

Source: Reference 11.

<sup>a</sup> Captive means used for subsequent processes on site. Merchant means sold as a final product.

NA = not available

Note: This list is subject to change as market conditions change, facility ownership changes, or plants are closed down. The reader should verify the existence of particular facilities by consulting current listings or the plants themselves. The level of benzene emissions from any given facility is a function of variables such as throughput and control measures; and should be determined through direct contacts with plant personnel. Data represent producers, locations, and capacities as of January 1993.

plants are similar, with smaller amounts of benzene being emitted from natural gas concentrate-using plants.

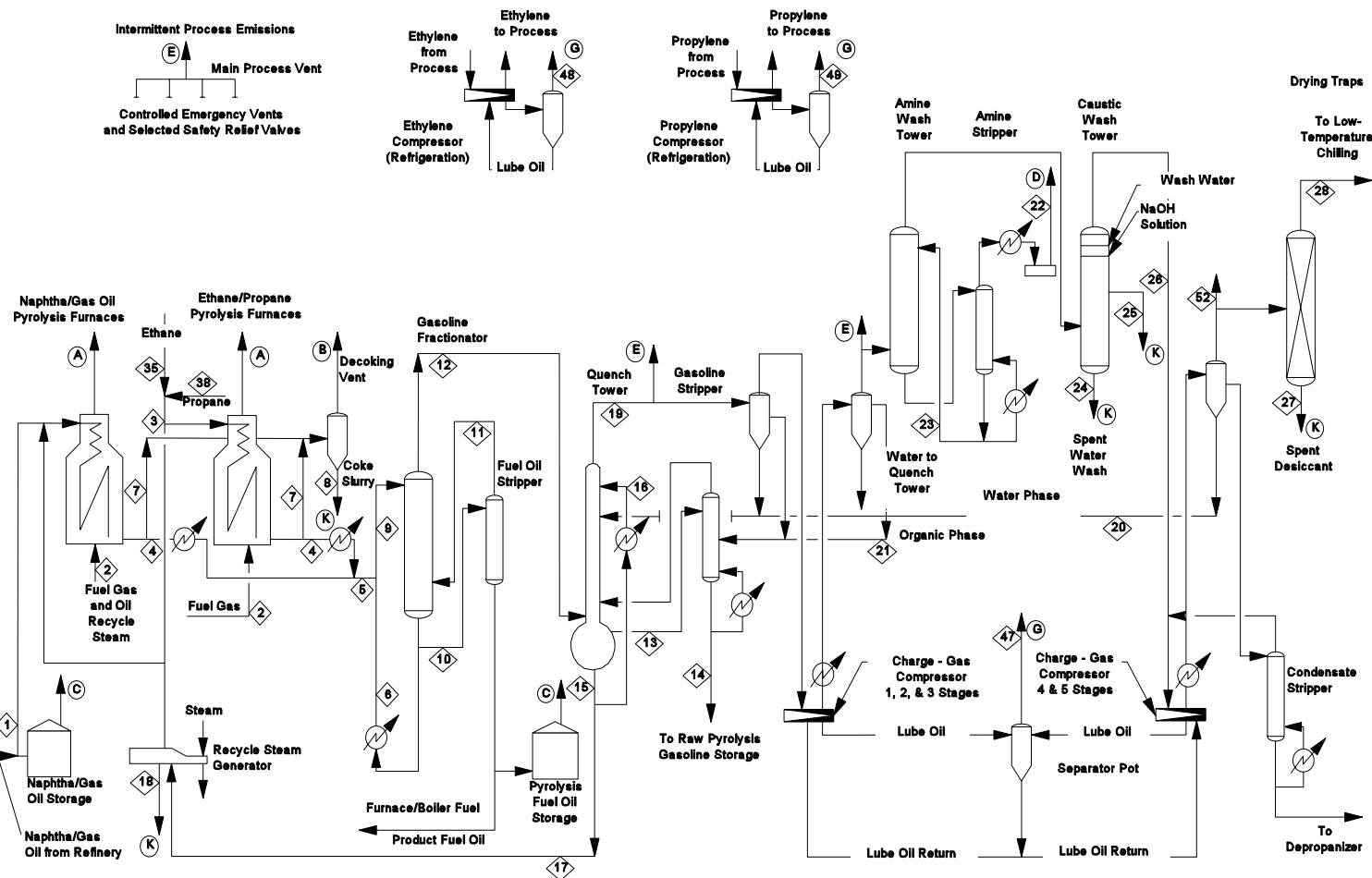
### Ethylene/Pyrolysis Gasoline Production

A process flow diagram for a plant producing ethylene from naphtha and/or gas oil is shown in Figure 4-5. Many older facilities use larger numbers of compressors (in parallel) than are shown in the flow diagrams in Figure 4-5. For reference, Table 4-3 lists stream descriptions and corresponding stream numbers in Figure 4-5. The description of the process is taken almost entirely from Reference 28.

Naphtha and/or gas oil (Stream 1), diluted with steam, is fed in parallel to a number of gas- or oil-fired tubular pyrolysis furnaces. The fuel gas and oil (Stream 2) for these furnaces are supplied from gas and oil fractions removed from the cracked gas in later separation steps. Ethane and propane, which are present in the cracked gas and are separated in later distillation steps (Streams 35 and 38), are combined and recycled (Stream 3) through a separate cracking furnace. The resulting cracked gas is combined with the cracked gas from the naphtha/gas-oil furnaces (Stream 5). The flue gas from the pyrolysis furnaces is vented (Vent A on Figure 6).

During operation, coke accumulates on the inside walls of the reactor coils, and each furnace must be periodically taken out of service for removal of the accumulated coke. Normally, one furnace is out of service for decoking at all times. Decoking is accomplished by passing steam and air through the coil while the furnace is maintained at an elevated temperature, effectively burning the carbon out of the coil. While a furnace is being decoked, the exhaust is diverted (Stream 7) to an emissions control device (Vent B) whose main function is to reduce particulate emissions. The collected particles are removed as a slurry (Stream 8).

The cracked gas (Stream 4) leaving the pyrolysis furnaces is rapidly cooled (quenched) to 482 to 572°F (250 to 300°C) by passing it through transfer-line exchangers,



Note: The stream numbers on the figure correspond to the discussion in the text for this process. Letters correspond to potential sources of benzene emissions.

Figure 4-5. Process Flow Diagram for Ethylene Production from Naphtha and/or Gas-Oil Feeds

Source: Reference 28.

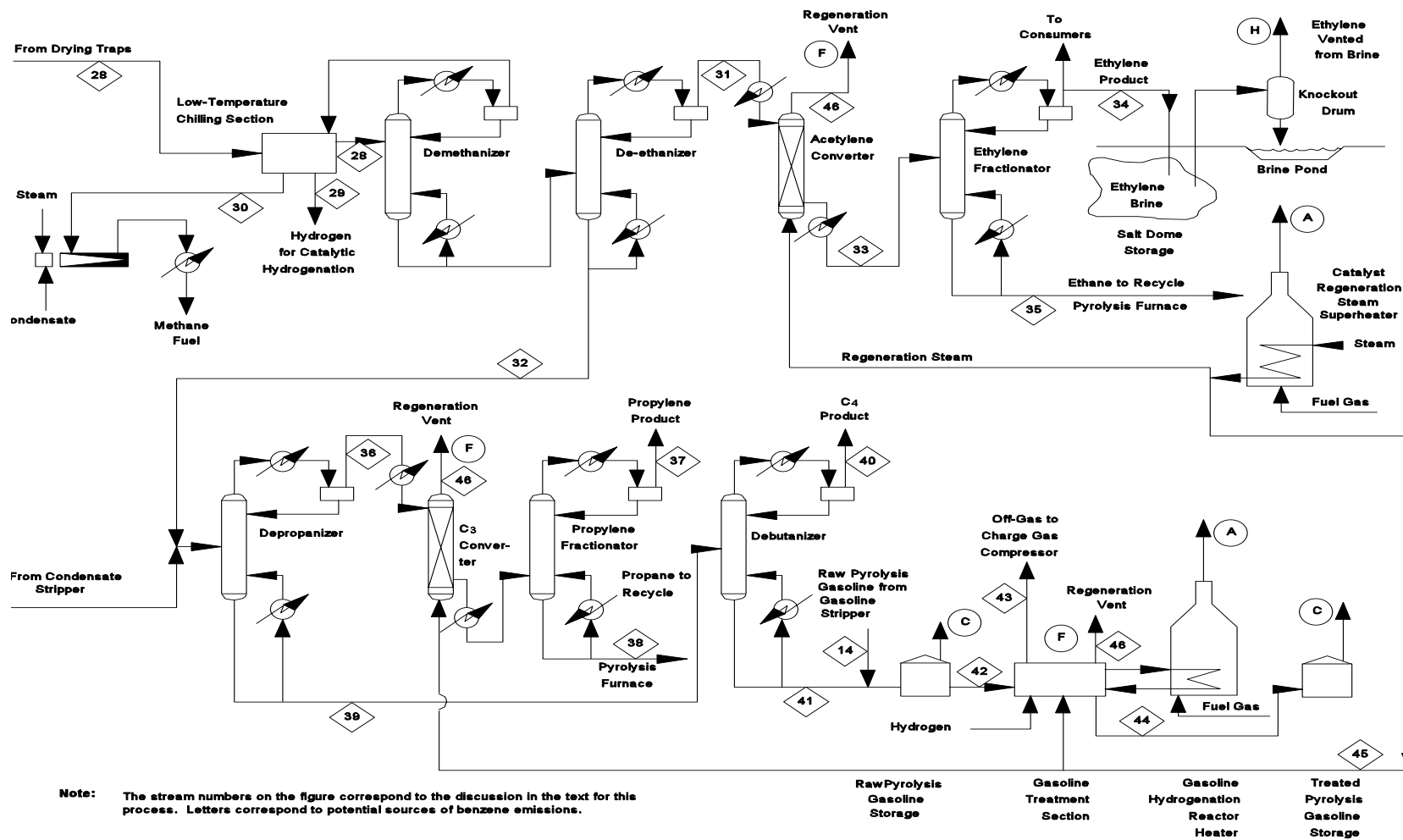


Figure 4-5. Process Flow Diagram for Ethylene Production from Naphtha and/or Gas-Oil Feeds, continued

Source: Reference 28.